भारतीय मानक **IS 3039 : 2024**

Indian Standard

जहाज़ निर्माण के लिए संरचनात्मक इस्पात — विशिष्टि

(तीसरा पुनरीक्षण)

Structural Steel for Ship Construction — Specification

(Third Revision)

ICS 47.020.05

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Wrought Steel Products Sectional Committee, MTD 04

FOREWORD

This Indian Standard (Third Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Wrought Steel Products Sectional Committee had been approved by the Metallurgical Engineering Division Council.

This standard was first published in 1965 and revised in 1980 and 1988. While reviewing this standard, in the light of experience gained during these years, the Committee decided to revise it to bring it in line with the present practices being followed by the ship building industry and global standards of structural steels for ship construction.

The following major changes have been made in this revision:

a) Scope of standard has been revised;

b) More definitions have been added in terminology **3**;

c) Clause **5** on designation and grades has been added;

d) Clauses **6** and **7** have been modified;

e) Chemical and mechanical properties of normal strength grades and higher strength grades have been added; and

f) A section on plates with through thickness properties has been added.

The composition of the Committee responsible for formulation of this standard is given in Annex B.

For the purpose of whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

STRUCTURAL STEEL FOR SHIP CONSTRUCTION — SPECIFICATION

(Third Revision)

1 SCOPE

1.1 This standard specifies the requirements for hot-rolled structural steel plates, sections, flats and bars used in ship construction.

1.2 This standard does not cover rivet bars, bolts and plain shafts used in shipbuilding.

1.3 Plate and strip which is coiled after hot rolling and subsequently uncoiled, cold flattened and cut to the required dimensions are also subject to the appropriate requirements of this specification.

1.4 The requirements apply to plates and wide flats not exceeding 100 mm in nominal thickness and sections and bars not exceeding 50 mm in nominal thickness.

2 REFERENCES

The standards listed in Annex A contain provisions, which through references in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of these standards.

3 TERMINOLOGY

For the purpose of this standard, the definitions given in various parts of IS 1956 and the following shall apply.

3.1 Micro-alloying Elements — Elements, such as niobium, vanadium and titanium or boron (for steel with YS > 690 Mpa) added singly or in combination to obtain high strength combined with better toughness, formability and weldability.

3.2 Weldability — A metallic substance is considered to be weldable by a given process and for the given purpose, when metallic continuity to a stated degree can be obtained by welding using a suitable procedure, so that the joints comply with the requirements specified in regard to both their local properties and their influence on the construction of which they form apart.

3.3 As Rolled (AR) — The normal rolling of steel with no specific control of rolling temperature followed by air cooling. The rolling and finishing temperatures are typically in the austenite recrystallization region (above the Ar_3 temperature) of the steel. The strength and toughness properties of steel produced by this process are generally less than steel rolled with other temperature controlled advanced rolling processes.

3.4 Controlled Rolling (CR) — A hot rolling process in which the temperature of the steel and its reduction ratio are controlled in order to achieve fine grain microstructure and optimum mechanical properties.

3.5 Normalizing Rolling (NR) — A hot rolling process in which the final deformation is carried out within a certain temperature range equivalent to normalizing temperature, leading to a material condition equivalent to that obtained after normalizing, such that the specified mechanical properties would still be met in the event of any subsequent normalizing.

3.6 Thermo-Mechanical Controlled Processing (TM) — A hot rolling process in which the final deformation is carried out in a certain temperature range leading to a material condition with certain properties which cannot be achieved or repeated by heat treatment alone, and such deformation is followed by cooling, possibly with increased cooling rates with or without tempering, self-tempering included.

NOTE — Subsequent heating above 580 °C typically can lower the strength values.

3.7 Normalizing (N) — A normalizing heat treatment consist of heating steel from an appropriate temperature below the transformation range to the proper temperature above the transformation range, holding for a sufficient time to effect the desired transformation and then subsequent cooling the steel in air. The process improves the mechanical properties of as-rolled steel by refining the austenitic grain size, provided that the steel is produced by fine austenitic grain size practice.

3.8 Quenching and Tempering (QT) — Quenching involves a heat treatment process in which steel is heated to an appropriate temperature above Ac_3 to austenitising temperature of steel and then cooled with an appropriate quenching media for the purpose of hardening the microstructure.

Tempering subsequent to quenching is a process in which the steel is reheated to an appropriate temperature not higher than the Ac_1 to restore toughness properties by improving the microstructure.

3.9 Fine-Grain Steel — Steel with fine-grain structure with an equivalent index of ferritic grain size ≥ 5 determined in accordance with IS 4748.

3.10 Z Grade Steel — When plate material, intended for welded construction, will be subject to significant strains in a direction perpendicular to the rolled surfaces, it is recommended that consideration be given to the use of special plate material with specified through thickness properties. These strains are usually associated with thermal contraction and restraint during welding, particularly for full penetration 'T'-butt welds, but may also be associated with loads applied in service or during construction. Where these strains are of sufficient magnitude, lamellar tearing may occur.

SECTION 1 GENERAL REQUIREMENTS

4 SUPPLY OF MATERIAL

General requirements relating a supply of structural steel shall conform to IS 8910.

5 DESIGNATION AND GRADES

5.1 The steels are classified into two set of grades on the basis of yield strength as normal strength grades with a specified minimum yield strength 235 Mpa and higher strength grades with a specified minimum yield strength 315 Mpa or 355 Mpa or 390 Mpa. Further, on the basis of mode of de-oxidation, the grades of normal strength and higher strength are classified into A, B, D and E and A, D, E and F respectively.

5.2 Designation

5.2.1 *Normal Strength Grades*

The product designation shall include A, B, D or E on the basis of de-oxidation.

5.2.2 *Higher Strength Grades*

The product designation shall follow the sequence comprising grade classification on basis of de-oxidation, H to indicate higher strength and tensile strength (first two digits of rounded off value, for example 32 for 315 N/mm^2).

The designations of higher strength grades include:

a) AH32, AH36, AH 40;
b) DH32, DH36, DH 40;
c) EH32, EH36, EH 40; and
d) FH32, FH36, FH 40.

5.2.3 Steels intended to have guaranteed through thickness properties shall include the supplementary suffix Z25 or Z35 in the designation.

Example:

D36 Z35

6 MANUFACTURE

6.1 Unless otherwise specified steel shall be manufactured by any process at the discretion of the manufacturer. However, the following shall apply:

6.1.1 Grades D, E, AH32, AH36, AH40, DH32, DH36, DH40, EH32, EH36, EH40, FH32, FH36 and FH40 shall be made using a fine grain practice. For normal strength grades aluminum shall be used to obtain grain refinement. For higher strength grades aluminum, vanadium, niobium or titanium may be used for grain refinement.

6.1.2 Plates in all thicknesses ordered to Grade E shall be normalized or thermo-mechanical control processed (TM). Plates over 35 mm in thickness ordered to Grade D shall be normalized, control rolled, or thermo-mechanical control processed (TM).

6.1.3 Plates in all thicknesses ordered to Grades EH32 and EH36 shall be normalized, or thermo-mechanical control processed (TM). Plates in all thicknesses ordered to Grade EH40, FH32, FH36 and FH40 shall be normalized, thermo-mechanical control processed (TM) or quenched and tempered. Plates ordered to Grades AH32, AH36, AH40, DH32, DH36, and DH40 shall be normalized, control rolled, thermo-mechanical control processed (TM) or quenched and tempered.

6.1.4 Unless otherwise agreed to between the manufacturer and the purchaser, the reduction ratio of continuously cast slab to plate is as below:

a) For concast slabs, a minimum reduction ratio 3 : 1 shall be used from cast slab to plate or size of the slab is to be proportional

to the dimensions of the final product such that the reduction ratio is minimum 3 : 1.

7 FREEDOM FROM DEFECTS

7.1 All materials shall be free from cracks, surface flaws, segregation, lamination, pipe and other defects which will be harmful to the service of the material.

7.2 If agreed between the manufacturer and the purchaser Surface defects may be removed by local grinding provided that:

a) The thickness at no place is reduced to less than 93 percent of the nominal thickness, and in no case by more than 3 mm;

b) Each single ground area does not exceed 0.25 m^2;

c) The total area of local grinding does not exceed two percent of the total surface area of the plate; and

d) The ground areas have smooth transitions to the surrounding surface.

7.2.1 Where necessary, the entire surface may be ground to a maximum depth as given by the under thickness tolerances of the product. The extent of such rectification is to be agreed in each case with customer and is to be carried out as agreed between the purchaser and the manufacturer/supplier. The customer may request that complete removal of the defect is proven by suitable nondestructive examination of the affected area.

7.3 Surface defects, which cannot be removed in the manner indicated in **7.2** and if agreed between the manufacturer and the purchaser, may be removed by chipping and grinding followed by weld-depositing of metal, provided that:

a) Before welding the thickness of metal shall at no place be reduced by more than 20 percent of the nominal thickness;

b) Each single weld does not exceed 0.125 m^2;

c) The total area of welding does not exceed 2 percent of the surface of the side involved;

d) The distance between any two welds is not less than their average width;

e) The welds are of reasonable size and made with an excess layer of beads which is then ground smooth to the surface level;

f) Elimination of the defect is proven by suitable nondestructive examination of the affected area;

g) Welding is carried out by an approved procedure and by competent operators using approved electrodes and the repaired area is ground smooth to the correct nominal thickness; and

h) When agreed between the purchaser and the manufacturer/the supplier, the item is normalized or otherwise suitably heat treated after welding and grinding.

7.4 Surface inspection and verification of dimensions are the responsibility of the steel manufacturer and are to be carried out on all materials prior to dispatch.

8 CHEMICAL COMPOSITION

8.1 The ladle analysis of steel when analyzed in accordance with the relevant parts of IS 228 or any other established instrumental/chemical method shall be as given in Table 3 for normal strength steels and Table 7 for higher strength steels. In case of dispute the procedure given in relevant parts of IS 228 shall be the referee method. However, where the method is not given in IS 228 or its relevant parts, the referee method shall be as agreed to between the purchaser and the manufacturer.

8.2 Elements designated as residual elements in the individual specifications shall not be intentionally added to the steel. The content of such elements shall be reported.

8.3 Product Analysis

The product analysis shall be carried out on the finished product from the standard position. Permissible variation in case of such product analysis from the limits specified under in Table 3 and Table 7 shall be as given in Table 1.

8.3.1 If a product analysis is required by the purchaser at least one sample of product shall be taken from each heat.

9 SELECTION AND PREPARATION OF TEST SAMPLES

9.1 The locations for taking test samples for plates, sections and bars are indicated in Fig. 1. Alternatively, in case of sections, the samples may be taken from the web. For testing of plates (including plates produced from HR coils) tensile test pieces shall be cut in transverse to rolling direction.

Table 1 Product Analysis

(*Clause* 8.3)

Sl No.	Constituent	Permissible Variation Over the Specified Limit
		Percent, *Max*
(1)	(2)	(3)
i)	C < 0.20	0.02
ii)	C ≥ 0.20	0.03
iii)	Mn	0.05
iv)	S	0.005
v)	P	0.005
vi)	Si	0.03
vii)	N	0.005
viii)	Cr	0.04
ix)	Mo	0.01
x)	Ni	0.03
xi)	Cu	0.02
xii)	Nb	0.01
xiii)	V	0.01
xiv)	Ti	0.01

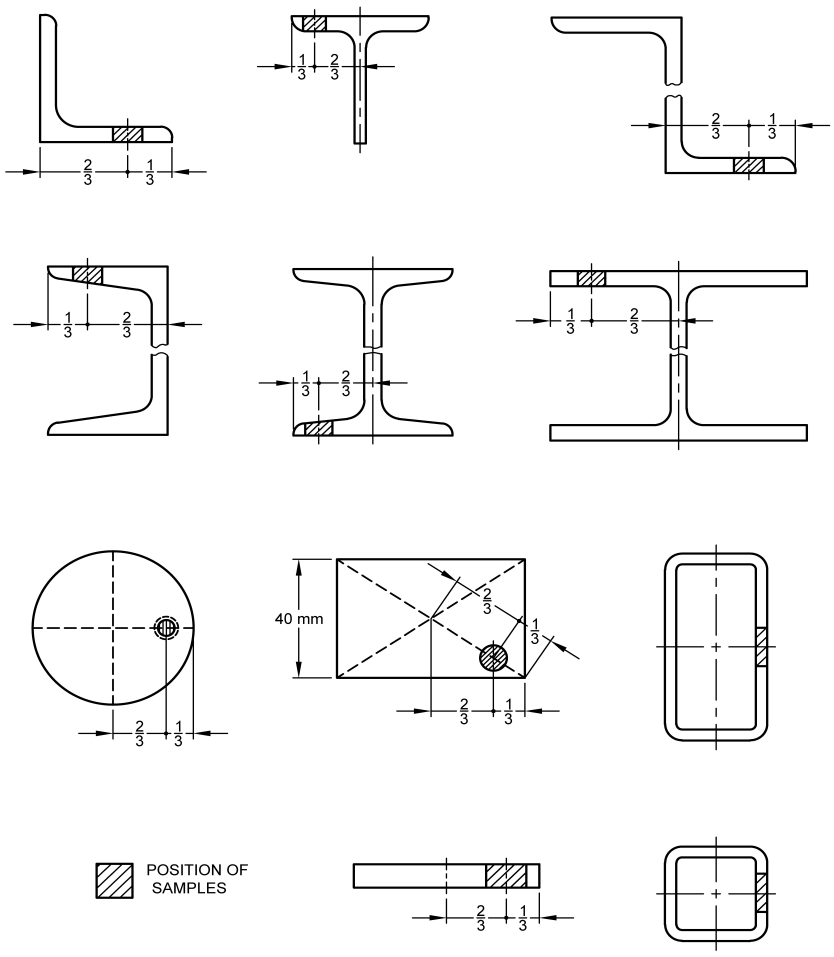

FIG. 1 STRUCTURAL STEEL SECTIONS, POSITION AND ORIENTATION OF SAMPLE

9.2 Whenever practicable, the rolled surface of the steel shall be retained on the two opposite sides of the test samples.

9.3 In case of the flat test samplers for tensile test, both surfaces are normally to be left on the test samples for strips and plates up to 32 mm thick. At least one rolled surface shall be left on rectangular test samples taken from plates exceeding 32 mm in thickness, round test samples are permitted, but should only be adopted for thickness exceeding 20 mm.

9.4 In case of flats up to 16 mm thick, the test sample shall undergo, if possible, no machining whatever, prior to use as a test piece. If this is not possible, the test sample shall undergo the minimum amount of machining.

9.5 Bars below 28 mm shall be tested without machining. In case of bars having diameters or thickness between 28 mm and 71 mm, the bars may be symmetrically reduced by machining. For bars having diameters or thickness exceeding 71 mm, the test sample may be taken from the position shown in Fig. 1.

9.6 Test samples shall be cut in such a manner that the deformation is avoided as far as possible. If shearing of flame-cutting is employed, an adequate allowance shall be left for removal by machining.

9.7 Test samples shall not be subjected to heat treatment unless the material from which they are cut is similarly and simultaneously treated with the material before testing. Any slight straightening of test samples which may be required shall be done cold.

10 TENSILE TEST

10.1 Number of Tensile Tests

10.1.1 For as rolled plates/normalized rolled plates/TMCP rolled plates: One tensile test shall be made from each cast/heat unless the cast/heat is greater than 50 tonne in which case one extra test shall be made from each 50 tonne or part thereof. Additional tests are to be made from plates for every variation of 10 mm in thickness of material from the same cast heat. For sections and bars, additional tests are to be made for every variation of 20 percent in thickness/diameter.

10.1.2 For normalized plates: One tensile test shall be made on each as rolled plate.

10.1.3 For quenched and tempered plates: One tensile test shall be made on each plate quenched and tempered.

10.2 Tensile Test Pieces

The tensile strength, yield strength and percentage elongation of steel shall be determined from standard test pieces cut crosswise from plates and strips and lengthwise from sections, flats and bars. The test shall be carried out as on the standard test pieces prepared in accordance with IS 1608 (Part 1).

10.2.1 As a rule, test pieces with a proportional gauge length complying with the requirements $L_0 = 5.65\sqrt{S_0}$ should be used for the tensile test, where L_0 is the gauge length and S_0 is the cross-sectional area of the test piece.

10.2.2 Test pieces with a non-proportional gauge length, other than $5.65\sqrt{S_0}$ may be used in which case, the elongation values shall be converted to $5.65\sqrt{S_0}$ in accordance with IS 3803 (Part 1).

10.2.3 Should a tensile test piece break outside the middle half of the gauge length [*see* IS 1608 (Part 1)] and the percentage elongation obtained is less than that specified, the test may be discarded at the manufacturer/supplier's option and another test made from the sample plate, strip, section, flat or bar.

11 IMPACT TEST

11.1 Impact test shall normally be carried out on products having thickness/diameter greater than or equal to 6 mm. The test specimen is parallel to the direction of rolling and the base closer to the rolled surface is more than 1 mm from it. The notch axis shall be perpendicular to the rolled surface.

11.1.1 Impact test for thickness less than 6 mm is not required. However, in case it is required by purchaser, the test value may be mutually agreed between purchaser and manufacturer at the time of order.

11.1.2 The tabulated values are for standard specimens 10 mm × 10 mm. For plate thicknesses lower than 10 mm, sub-size specimens with reduced requirements may be taken as follows:

a) Specimen dimensions 10 mm × 7.5 mm:
   - 5/6 of the tabulated value;
b) Specimen dimensions 10 mm × 5.0 mm:
   - 2/3 of the tabulated value; and
c) Specimen dimensions 10 mm × 2.5 mm:
   - 1/2 of the tabulated value.

11.2 This test is carried out using a V-notch test piece as per IS 1757 (Part 1) the value for consideration being the arithmetic mean of the results obtained on three test pieces taken side by

side from the same product (*see* Table 5 and Table 10).

11.3 The test sample shall be taken from the thickest product. If the test sample taken from the thickest product rolled from a cast meets the requirements, the whole cast shall be deemed to meet the requirements of the test, if not, the test shall be performed on a section of next lower thickness rolled from the same cast, if it meets the requirements specified, this particular thickness as also other sections of lower thickness shall be deemed to satisfy this specification. If this thickness also does not meet the requirements, the test shall be carried out on the next lower thickness and so on, because the toughness of the product will be dependent on the rolling direction as well as on the section size.

12 OTHER TESTS

12.1 The material may be subjected to non-destructive testing like UT (ultrasonic testing) to determine the soundness of material as per any national or international standard, subject to mutual agreement between the purchaser and the manufacturer/supplier.

12.2 Metallurgical tests for grain size, directionality, inclusion content may be carried out subject to mutual agreement between the purchaser and the manufacturer/supplier.

13 RETEST

13.1 If a test does not give the specified results, two additional test shall be carried out at random on the same lot. Both retests shall conform to the requirements of this standard; otherwise the lot shall be rejected.

13.2 Re-heat Treatment

If any heat treated material fails to meet the mechanical requirements specified, the supplier may re-heat treat the material and in that case, all mechanical properties shall be re-evaluated.

14 STEEL WITH GUARANTEED THROUGH THICKNESS PROPERTIES – 'Z' GRADE STEEL

Requirements for 'Z' grade plate material are specified in Section 4.

15 DIMENSIONS

Unless otherwise agreed to between the purchaser and the manufacturer, nominal dimensions of rolled product(s) conforming to this standard shall be in accordance with the relevant Indian Standard. Currently available Indian Standards are listed in Table 2.

Table 2 Indian Standards which Give Nominal Dimensions of Rolled Steel Products

(*Clause* 15)

Sl No.	Product	Relevant Indian Standard
(1)	(2)	(3)
i)	Beam, column, channel and angle sections including parallel beam and column sections	IS 808
ii)	Tee bars	IS 1173
iii)	Bulb angles	IS 1252
iv)	Plates, sheets and strips and flats	IS 1730
v)	Round and square bars	IS 1732
vi)	Bulb flats	IS 1863
vii)	Channel sections	IS 3954
viii)	Hollow sections	IS 4923
ix)	Plates for ship's hull structure	IS 5488

16 TOLERANCES

Unless otherwise agreed to between the purchaser and the manufacturer, the rolling and cutting tolerances for steel products conforming to this standard shall be those specified in IS 1852 (with minimum allowable thickness tolerance of 0.3 mm on lower side) except the parallel flange beams and columns for which the tolerances shall be as per IS 12779. Other tolerance may be followed within the total tolerance range as specified in IS 1852 and IS 12779 as applicable.

17 CALCLUATION OF MASS

The mass of steel shall be calculated on the basis that steel weight 7.85 g/cm^3.

18 MARKING

18.1 Every finished product shall be clearly marked by manufacturer in at least one place. The following particulars shall be marked on each product, unless agreed otherwise:

a) Manufacturer's name, or trade-mark;

b) Grade of steel;

c) Cast number or heat number (enable the material to be traced to its original heat); and

d) Size of sheets or plates.

Where a number of steel material is securely fastened together in bundles, the manufacturer may, subject to the agreement with the purchaser, mark only the top product piece of each bundle, or alternatively, a firmly fastened durable label containing the marking details may attached to each bundle.

18.2 Plates produced to a normalized heat treatment or normalizing rolling condition shall be marked with the suffix N to indicate that the plates have been normalized.

18.3 Plates produced to a control rolled condition shall be marked with the suffix CR to indicate that the plates have been control rolled.

18.4 Plates produced to a thermo-mechanical control processed condition shall be marked with the suffix TM to indicate that the plates have been thermo-mechanical control processed.

18.5 Plates produced to a quenched and tempered heat treatment condition shall be marked with the suffix QT to indicate that the plates have been quenched and tempered.

18.6 Each product with the exception of round, square, hexagonal bars and flats shall carry a tag or be marked with the manufacturer's name or trade mark. Bars and flats shall carry a tag bearing the manufacturers name or trade mark. Designation of steel should also be similarly marked on the product or tag.

18.7 Every heavy, medium structural mill and plate mill product shall be marked with a cast/heat number. Plates produced from strip in coil form shall me marked with cast/heat number on top plate of each pile/packet.

18.8 BIS Certification Marking

The products(s) conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder and the products may be marked with the Standard Mark.

SECTION 2 NORMAL STRENGTH STEELS

19 GENERAL

19.1 This section covers normal strength grades designated as A, B, D and E.

19.2 Steel shall comply in all respects with the requirements specified in Section 1 and Section 2 of this standard and shall be subjected to both chemical analysis, mechanical tests and other tests.

20 CHEMICAL COMPOSITION

The ladle analysis limits and de-oxidation practice shall comply with the requirement of Table 3.

Table 3 Chemical Composition Limits and Deoxidation Practice for Normal Strength Steels

(*Clauses* 8.1, 8.3 *and* 20)

Sl No.	Steel Designation	Mass Fraction, Based Upon Ladle Analysis[1] Percent, *Max*						De-oxidation Practice
		C[2]	Si	Mn[2]	P	S	Al	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	A	0.21[3]	0.50	2.5 × C *Min*	0.035	0.035	—	For $t \leq 50$ mm: Killed or semi-killed For $t > 50$ mm: Killed
ii)	B	0.21	0.35	0.80 *Min*[4]	0.035	0.035	—	For $t > 50$ mm: Killed For $t \leq 50$ mm: Killed or semi-killed
iii)	D	0.21	0.10 to 0.35	0.60 *Min*	0.035	0.035	0.020 *Min*[5]	For $t > 25$ mm: Killed and fine grain treated
iv)	E	0.18	0.10 to 0.35	0.70 *Min*	0.035	0.035	0.020 *Min*[5]	Killed and fine grain treated

NOTE — Where additions of any other elements are made as part of the steel-making practice, the content of each element is to be reported.

21 CONDITION

The condition of supply shall comply with the requirements given in Table 4.

Table 4 Condition of Supply

(*Clause* 21)

Sl No.	Steel Designation	Thickness mm	Plates	Sections
(1)	(2)	(3)	(4)	(5)
i)	A & B	≤ 50	AR, NR, N, TM, CR	AR, NR, N, TM, CR
		> 50 ≤ 150	AR*), NR, N, TM, CR	AR*), NR, N, TM, CR
ii)	D	≤ 35	AR, NR, N, TM, CR	AR, NR, N, TM, CR
		> 35 ≤ 150	NR, N, TM, CR	AR*), NR, N, TM, CR
iii)	E	≤ 150	N, TM, CR	AR*), NR*), N, TM, CR

[1] Composition in percentage mass by mass maximum unless shown as a range or as a minimum.

[2] Percent C + 1/6 Mn shall not exceed 0.40.

[3] Carbon content of 0.23 percent maximum is acceptable for Grade A for shapes and bars.

[4] For Grade B steel when fully killed lower limit of manganese to be reduced to 0.60 percent minimum.

[5] For semi-killed steel, silicon shall be less than 0.10 percent. For killed steel, when the steel is killed by aluminium alone, the total aluminium content shall not be less than 0.02 percent. When the steel is killed by silicon alone, the silicon content shall not be less than 0.10 percent. When the steel is silicon-aluminium killed, the silicon content shall not be less than 0.03 percent and total aluminium content shall not be less than 0.01 percent.

*) Products may be supplied in this condition when mutually agreed between the manufacturer/the supplier and the purchaser.

22 MECHANICAL PROPERTIES

22.1 The mechanical properties shall comply with the requirements given in Table 5.

22.1.1 In case of sections, the thickness of which is not uniform throughout the profile, the limit of sizes given in Table 5 shall be applied according to the actual maximum thickness of the piece adopted for testing.

22.2 For impact testing, the maximum size of a test unit shall be as given in Table 6. The direction of impact test sample shall be in longitudinal to the rolling direction. No individual measurement of impact test shall be less than 70 percent of the value indicated in Table 5.

22.3 For Grades A and B where plate is supplied from coil, results of the tensile test can be transposed from the certificate of the coil manufacture onto the certificate issued by the re-processor. If the coil mass exceeds 50 tonne, testing will additionally be required from two locations representing the start and end of the coil. For Grades D and E, the mechanical properties must be sampled from the de-coiled plate in accordance with the frequency specified in Table 6.

22.4 For plates of thickness exceeding 50 mm in Grade E steel, one tensile test is to be made on each plate.

Table 5 Mechanical Properties

(*Clauses* 11.2, 22.1, 22.1.1 *and* 22.2)

Sl No.	**Steel Designation**	**Yield Strength** MPa *Min*	**Tensile Strength** MPa	**Elongation Lo = 5.65√So** Percent *Min*	**Test Temperature** °C	**Notched bar impact energy**, J, *Min*[5]		
						$t \leq 50$	$50 < t \leq 70$	$70 < t \leq 100$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	A	235	400 to 520[2]	22[1]	+ 20	–	34[4]	41[5]
ii)	B				0	27[3]	34	41
iii)	D				- 20	27	34	41
iv)	E				- 40	27	34	41

t = thickness of product in mm.

[1] For full thickness flat test pieces with width 25 mm and gauge length 200 mm, the minimum elongation (%) is reduced to the following values:

Thickness, mm	≤ 5	> 5 ≤ 10	>10 ≤ 15	>15 ≤ 20	> 20 ≤ 25	> 25 ≤ 30	> 30 ≤ 40	> 40 ≤ 50	> 50
Elongation Value, Percent	14	16	17	18	19	20	21	22	To be agreed between manufacturer and purchaser at the time of order

[2] For Grade A sections and bars, the upper limit of the tensile strength may be 550 MPa or as agreed between the purchaser and the manufacturer/the supplier.

[3] Notch impact tests are generally not required for Grade B steels with thickness of 25 mm or less.

[4] For Grade A products with thickness in excess of 50 mm, notch impact tests are not required provided that the steel has been fine grain treated and normalized or TM.

[5] Impact tests are not required for plates less than 6 mm in thickness.

Table 6 Test Frequency for Impact Testing of Normal Strength Steel

(*Clauses* 22.2 *and* 22.3)

Sl No.	Grade	Thickness, *t* mm	Plates	Sections
(1)	(2)	(3)	(4)	(5)
i)	A	$t \leq 50$	Not required	Not required
		$50 < t \leq 150$	50 tonne	Not required
ii)	B	$t \leq 25$	Not required	Not required
		$25 < t \leq 150$	50 tonne[1)2)]	50 tonne[2)]
iii)	D	$t \leq 150$	50 tonne[1)2)]	50 tonne[2)]
iv)	E	$t \leq 150$	Each plate	25 tonne[3)]

SECTION 3 HIGHER STRENGTH STEELS

23 GENERAL

23.1 This section covers higher-strength grades designated as AH 32 to FH 40 as given at **5.2.2**.

23.2 Steel shall comply in all respects with the requirements specified in Section 1 and Section 3 of this standard and shall be subjected to both chemical analysis, mechanical tests and other tests.

24 CHEMICAL COMPOSITION

24.1 The ladle analysis limits and de-oxidation practice shall comply with the requirement of Table 7. The steel grades shall be made with fine grain practice and fully killed.

24.2 When required, the carbon equivalent value shall be calculated from the heat analysis using the formula:

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15} (\%)$$

24.2.1 For thermo-mechanical control processed higher strength steels, the carbon equivalent shall be determined from the heat analysis and shall conform to the requirements given below:

Sl No.	*Steel Designation*	*Carbon Equivalent, Percent, Max for Thickness* (*t*), *in* mm	
		$t \leq 2.0$ in (50 mm)	$t > 2.0$ in (50 mm) $t \leq 4.0$ in (100 mm)
(1)	(2)	(3)	(4)
i)	AH32, DH32, EH32, FH32	0.36	0.38
ii)	AH36, DH36, EH36, FH36	0.38	0.40
iii)	AH40, DH40, EH40, FH40	0.40	0.42

[1)] Maximum 25 tonne for plates over 50 mm in thickness supplied in the normalizing rolled (NR) condition.

[2)] Maximum 25 tonne for plates and sections supplied in the as rolled (AR) condition.

[3)] Maximum 15 tonne for sections supplied in the as rolled (AR) or normalizing rolled (NR) condition.

24.3 The cold cracking susceptibility, P_{cm}, may be used instead of the carbon equivalent for evaluating weldability, in which case the following formula is to be used for calculating the P_{cm} from the ladle analysis:

$$P_{cm} = C + \frac{Si}{30} + \frac{Mn + Cr + Cu}{20} + \frac{Ni}{60} + \frac{Mo}{15} + \frac{V}{10} + 5B\ (\%)$$

The maximum allowable P_{cm} is to be agreed at the time of order and is to be included in the manufacturing specification and reported on the test certificate.

24.4 Small deviations in chemical composition from that given in Table 7 for plates exceeding 50 mm in thickness in Grades E36, E40, F36 and F40 may be agreed between the manufacturer and purchaser at the time of order.

25 CONDITION

The condition of supply shall comply with the requirements given in Table 8.

26 MECHANICAL PROPERTIES

26.1 The mechanical properties shall comply with the requirements given in Table 9.

26.1.1 In case of sections, the thickness of which is not uniform throughout the profile, the limit of sizes given in Table 10 shall be applied according to the actual maximum thickness of the piece adopted for testing.

26.2 For impact testing, the maximum size of a test unit shall be as given in Table 10. The direction of impact test sample shall be in longitudinal to the rolling direction. No individual measurement of impact test shall be less than 70 percent of the value indicated in Table 9.

Table 7 Chemical Composition Limits for Higher Strength Steel

(*Clauses* 8.1, 8.3, 24.1 *and* 24.4)

Sl No.	Steel Designation	Mass Fraction, Based Upon Ladle Analysis, Percent, *Max*													
		C	Si	Mn	P	S	Cr	Mo	Ni	Cu	Al[2)3)]	Nb[3)]	V[3)]	Ti	N
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
i)	AH32 DH32 EH32 AH36 DH36 EH36 AH40 DH40 EH40	0.18	0.50	0.90 to 1.60[1)]	0.035	0.035	0.20	0.08	0.40	0.35	0.02 *Min*	0.02 to 0.05	0.05 to 0.10	0.02	—
ii)	FH32 FH36 FH40	0.16	0.50	0.90 to 1.60	0.025	0.025	0.20	0.08	0.80	0.35	0.02 *Min*	0.02 to 0.05	0.05 to 0.10	0.02	0.009[4)]

[1)] Minimum manganese of 0.70 percent for thicknesses up to and including 12.5 mm for AH32, AH36, AH 40.

[2)] The total aluminum content may be determined instead of the acid soluble content. In such case the total aluminum content is to be not less than 0.020 percent.

[3)] The steel is to contain aluminum, niobium, vanadium or other suitable grain refining elements, either singly or in any combination. When used singly, the steel is to ontain the specified minimum content of the grain refining element. When used in combination, the specified minimum content of at least one grain refining element is applicable; the sum of Nb + V + Ti is not to exceed 0.12 percent.

[4)] Percent N is 0.012 percent maximum. When Al is present in steel.

Table 8 Conditions of Supply for High Strength Steel

(*Clause* 25)

Sl No.	Grade	Grain Refining Element	Thickness, *t* mm	Plates	Sections
(1)	(2)	(3)	(4)	(5)	(6)
i)	AH32, AH36	Al or Al + Ti	$t \leq 20$	AR, NR, N, TM, CR	AR, NR, N, TM, CR
			$20 < t \leq 35$	AR[1)], NR, N, TM, CR	AR, NR, N, TM, CR
			$35 < t \leq 150$	NR, N, TM, QT, CR	AR[1)], NR, N, TM, QT, CR
		Any, except Al or Al + Ti	$t \leq 12.5$	AR, NR, N, TM	AR, NR, N, TM
			$12.5 < t \leq 150$	NR, N, TM, QT, CR	AR[1)], NR, N, TM, CR,,QT
ii)	AH40	Any	$t \leq 12.5$	AR, NR, N, TM, CR	AR, NR, N, TM, CR
			$12.5 < t \leq 150$	NR, N, TM, QT, CR	NR, N, TM, QT, CR
iii)	DH32, DH36	Al or Al + Ti	$t \leq 20$	AR, NR, N, TM, CR	AR, NR, N, TM, CR
			$20 < t \leq 25$	AR[1)], NR, N, TM, CR	AR, NR, N, TM, CR
			$25 < t \leq 150$	NR, N, TM, QT, CR	AR[1)], NR, N, TM, QT, CR
		Any, except Al or Al + Ti	$t \leq 12.5$	AR, NR, N, TM, CR	AR, NR, N, TM, CR
			$12.5 < t \leq 150$	NR, N, TM, QT, CR	AR[1)], NR, N, TM, QT, CR
iv)	DH40	Any	$t \leq 150$	NR, N, TM, QT, CR	NR, N, TM, QT, CR
v)	EH32, EH36	Any	$t \leq 50$	N, TM, QT, CR	AR[1)], NR[1)], N, TM, QT
			$50 < t \leq 150$	N, TM, QT, CR	NR[1)], N, TM, QT, CR
vi)	FH32, FH36	Any	$t \leq 150$	N, TM, QT, CR	NR[1)], N, TM, QT, CR
vii)	EH40, FH40	Any	$t \leq 150$	N, TM, QT, CR	N, TM ,CR

[1)] Products may be supplied in this condition if mutually agreed between the manufacturer and the purchaser at the time of order.

Table 9 Mechanical Properties

(*Clauses* 26.1 *and* 26.2)

Sl No.	**Steel Designation** (*see* Note 2)	**Yield Strength** MPa *Min*	**Tensile Strength** MPa	**Elongation** (*see* Note 1) Lo = 5.65√So percent, *Min*	**Test Temperature** °C	**Notched Bar Impact Energy J**, *Min*		
						$t \leq 50$	$50 < t \leq 70$	$70 < t \leq 150$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
i)	AH32	315	440 to 590	22	0	31	38	46
ii)	DH32				-20			
iii)	EH32				-40			
iv)	FH32				-60			
v)	AH36	355	490 to 620	21	0	34	41	50
vi)	DH36				- 20			
vii)	EH36				- 40			
viii)	FH36				- 60			
ix)	AH40	390	510 to 650	20	0	41	46 (*see* Note 2)	55 (*see* Note 2)
x)	DH40				- 20			
xi)	EH40				- 40			
xii)	FH40				- 60			

NOTES

1 For full thickness flat test pieces with width 25 mm and gauge length 200 mm, the minimum elongation (percent) is reduced to the following values:

Sl No.	*Steel Designation*	*Thickness, t* (mm)								
		≤ 5	> 5 ≤ 10	>10 ≤ 15	> 15 ≤ 20	> 20 ≤ 25	> 25 ≤ 30	> 30 ≤ 40	> 40 ≤ 50	> 50
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
i)	AH32 DH32 EH32 FH32	14	16	17	18	19	20	21	22	To be agreed between manufacturer and the purchaser at the time of order
ii)	AH36 DH36 EH36 FH36	13	15	16	17	18	19	20	21	
iii)	AH40 DH40 EH40 FH40	12	14	15	16	17	18	19	20	

2 Subject to special approval the minimum tensile strength may be reduced to 470 MPa, for grades AH36, DH36, EH36 and FH36, in the TM condition when micro-alloying elements Nb, Ti or V are used singly and not in combination.

Table 10 Test Units for Impact Testing of High Strength Steel

(*Clauses* 11.2, 26.1.1 *and* 26.2)

Sl No.	Grade	Plates	Sections
(1)	(2)	(3)	(4)
i)	Grades A and D of all strength levels	50 tonne[1)2)]	50 tonne[2)]
ii)	Grades E and F of all strength levels	Each 'as rolled' plate	25 tonne[3)]

SECTION 4 PLATES WITH THROUGH THICKNESS PROPERTIES

27 GENERAL

27.1 These requirements are supplementary to the requirements for steels supplied as per Section 1 and Section 2 or Section 1 and Section 3. They apply to products with thicknesses greater than or equal 15 mm. The unit testing quantities shall be taken from Table 12.

27.2 Provision is made for two quality classes Z25 and Z35 based on specified minimum values for reduction of area in a through thickness tensile test. Quality class Z25 is intended for normal ship applications and Z35 for more severe applications.

28 MANUFACTURE

It is recommended that special steelmaking processes and techniques such as vacuum degassing, suitable low sulphur and/or sulphide shape control techniques are used.

29 CHEMICAL COMPOSITION

The steel grades shall made with fine grain practice and fully killed. The maximum sulphur content shall be 0.008 percent unless alternative methods of improving through thickness properties have been agreed between manufacturer and the purchaser.

30 TEST MATERIAL

30.1 Test material shall be taken close to the longitudinal centerline from one end of each as rolled plate or wide flat representing the test unit, (*see* Fig. 2) and Table 11.

30.2 The test material must be large enough to accommodate the preparation of six test pieces. Three test pieces shall be prepared while the rest of the sample remains for possible retest.

30.3 Test pieces shall be prepared in accordance with specification ISO 7778.

31 REDUCTION OF AREA

31.1 The average reduction in area value of three test pieces shall be determined and meet the specified minimum average value given in Table 12. One individual value may be below the specified minimum average value, provided that it is not less than the specified minimum individual value.

31.2 Re-test

If the results do not meet the specified requirements, three additional test pieces from the same sample may be tested. The test unit will then be accepted provided that the following conditions are met:

a) The average value of six test pieces meets the specified minimum average value;

b) Not more than two of six individual values are lower than the specified minimum average value; and

c) Not more than one of six individual values is lower than the specified minimum individual value.

31.3 Where batch testing is permitted and failure after retest occurs, the tested piece is to be rejected. Each remaining piece in the batch may be individually tested and accepted based on satisfactory results.

31.4 If the fracture of a test piece occurs in the weld or in the heat affected zone the test is regarded as invalid and shall be repeated on a new test piece.

1) Maximum 25 tonne for plates over 50 mm in thickness supplied in NR condition.

2) Maximum 25 tonne for plates and sections supplied in AR condition.

3) Maximum 15 tonne for sections supplied in AR or NR condition.

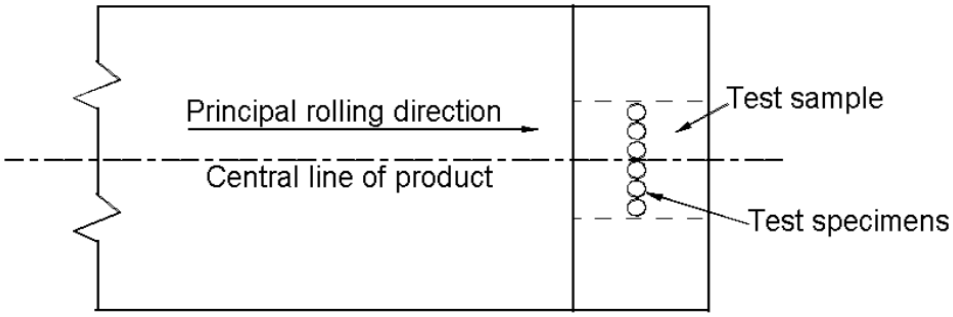

FIG. 2 PLATE AND WIDE FLAT SAMPLING POSITION

Table 11 Test Unit (Batch) Size Dependent on Product and Sulphur Content

(*Clause* 30.1)

Sl No.	**Product**	**S > 0.005 %**	**S ≤ 0.005 %**
(1)	(2)	(3)	(4)
i)	Plates	Each as rolled plate	Maximum 50 *t* of product of the same heat, thickness and condition of supply
ii)	Wide flats of nominal thickness ≤ 25 mm	Maximum 10 *t* of products of the same heat, thickness and condition of supply	Maximum 50 *t* of products of the same heat, thickness and condition of supply
iii)	Wide flats of nominal thickness > 25 mm	Maximum 20 *t* of products of the same heat, thickness and condition of supply	Maximum 50 *t* of products of the same heat, thickness and condition of supply

Table 12 Reduction of Area Acceptance Values

(*Clause* 27.1 *and* 31.1)

Sl No.	**Quality class**	**Z25**	**Z35**
(1)	(2)	(3)	(4)
i)	Minimum average	25 %	35 %
ii)	Minimum individual	15 %	25 %

ANNEX A

(*Clause* 2)

LIST OF REFERRED STANDARDS

IS No./Other Standard	*Title*
IS 228 (all parts)	Methods for chemical analysis of steel
IS 808 : 2021	Hot rolled steel beam, column, channel and angle sections — Dimensions and properties (*fourth revision*)
IS 1173 : 1978	Specification for hot rolled and slit steel tee bars (*second revision*)
IS 1252 : 1991	Hot rolled steel bulb angles — Dimensions (*first revision*)
IS 1608 (Part 1) : 2022/ISO 6892-1 : 2019	Metallic materials — Tensile testing: Part 1 Method of test at room temperature (*fifth revision*)
IS 1730 : 1989	Steel plates, sheets, strips and flats for structural and general engineering purposes — Dimensions (*second revision*)
IS 1732 : 1989	Steel bars, round and square for structural and general engineering purposes — Dimensions (*second revision*)
IS 1757 (Part 1) : 2020/ISO 148-1 : 2016	Metallic materials — Charpy pendulum impact test: Part 1 Test method (*fourth revision*)
IS 1852 : 1985	Specification for rolling and cutting tolerances for hot — Rolled steel products (*fourth revision*)
IS 1863 : 1979	Specification for rolled steel bulb flats (*first revision*)
IS 1956 (all parts)	Glossary of terms relating to iron and steel
IS 3803 (Part 1) : 2023/ISO 2566-1 : 2021	Steel — Conversion of elongation values: Part 1 Carbon and low-alloy steels (*third revision*)
IS 3954 : 1991	Hot rolled steel channel sections for general engineering purposes — Dimensions (*first revision*)
IS 4748 : 2021/ ISO 643 : 2019	Steel — Micrographic determination of the apparent grain size (*third revision*)
IS 4923 : 2017	Hollow steel sections for structural use — Specification (*third revision*)
IS 5488 : 1987	Dimensions and dimensional tolerances for hot-rolled steel plates for ship's hull structure (*first revision*)
IS 8910 : 2022/ ISO 404 : 2013	Steel and steel products — General technical delivery requirements (*second revision*)
IS 12779 : 1989	Rolling and cutting tolerances for hot rolled parallel flange beam and column sections — Specification
ISO 7778 : 2014	Through-thickness characteristics for steel products (*second edition*)

ANNEX B

(*Foreword*)

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